BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 04073

SUBJECT: Operation of Gamma-Ray Spectrometer and X-ray Fluorescence CSM Orbital Science Experiments on the Transearth Portion of Apollo 16 and 17 - Case 340

DATE: April 30, 1970

FROM: F. F. Tomblin

ABSTRACT

The CSM orbital science experiments for monitoring lunar surface X-ray and γ-ray emission on Apollo 16 and 17 can also provide galactic X-ray and γ-ray astronomy data which may be of scientific interest. It is suggested that three portions of the celestial sphere be viewed by both the X-ray and γ-ray detectors for 1/2 hour each with contingencies given for situations when more or less time is available. Also when the spacecraft is in the passive thermal control mode it is suggested that the X-ray experiment acquire data for 5 hours and the γ-ray experiment for 50 hours. Valuable data could also be obtained for shorter periods.

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MEMORANDUM FOR FILE

I. The Experiments

The CSM science complement includes experiments designed for surveying the lunar X-ray and gamma-ray emission characteristics. The X-ray spectrometer (S-161) consists of three proportional counters covering the energy range from 1 to 6 keV. The total area of the 3 detectors is 50 cm^2 collimated to a field of view 60° x 60°. Two of the detectors will be covered with aluminum and magnesium windows in addition to the beryllium window common to all 3 detectors. The Al and Mg windows provide spectral information between 1.0 and 1.3 keV because of the difference in the absorption edges of these materials. The percentage energy resolution varies inversely as the square root of the energy detected. At 6 keV it is $\sim$ 20%, at 1 keV it is 50%.

The gamma-ray detector (S-160) is a single NaI crystal optically coupled to a photomultiplier tube. This crystal has a 2π field of view and a surface area of 40 cm^2. The energy range covered will be 100 keV to 10 MeV. Even when viewing the moon, the cosmic gamma-ray flux should exceed any emission from natural lunar radioactivity.

With the exception of the field of view, these instruments are similar to those used in X-ray astronomy experiments in rockets and γ-ray astronomy experiments such as flown in balloons. Both instruments are configured such that they point in the same direction.

There are several non-lunar viewing requirements already established for these experiments to obtain background calibration data. Background for the X-ray experiment will be taken during 3 rolls to allow deep space to be viewed from lunar orbit. After transearth injection, a period of 6 hours is required to obtain sky background for the γ-ray experiment to determine the efficiency of the cosmic ray veto system and the contribution of cosmic γ-rays. There is also a requirement that the γ-ray experiment acquire 24 hours of galactic viewing data during the transearth segment of the mission.

II. Suggestions for X-ray and γ-ray Astronomy Data

It is suggested here that the X-ray and γ-ray experiments remain operational during a portion of the transearth segment of the mission to obtain astronomical data. Three portions of the celestial sphere are of special interest. These are 1) the galactic center, 2) the galactic pole, 3) the Crab Nebula. Each of these regions is well separated on the celestial sphere. Toward the galactic center the strong sources such as Sco XR-1 will make a single combined X-ray spectrum. Looking toward the galactic pole only the isotropic diffuse radiation should contribute in both X-rays and γ-rays. There are no known strong discrete X-ray sources in the region of the Crab Nebula which is located very near the galactic anticenter; however, the Crab will constitute only approximately 25% of the total flux at all energies for both detectors. This is observed because of the substantial contribution from the diffuse radiation. After these specific measurements additional X-ray and γ-ray data can be obtained in the passive thermal control (PTC) mode provided the X-ray detectors not be left on when looking at the sun.

The equinox periods (October or March) are particularly good for these stellar observations. The sun will be nearly 90° from both the galactic center and the Crab Nebula. The north galactic pole will be $\sim$ 25° from the sun in October and thus the south polar region should be viewed.

In the X-ray energy region covered, the data for Sco XR-1 may provide some indication of line emission which is due to the various K-α transitions. The existence of lines could be determined to better than 1% of the total continuum radiation. The pole region will give valuable detailed information on the spectral characteristics of the diffuse radiation in the X-ray region. It is doubtful that the gamma-ray detector will detect any significant flux from any of the discrete sources with the possible exception of the Crab.

These extended time observations are of value for two reasons. First they offer high statistical accuracy, particularly for the gamma-ray experiment. Secondly they obtain useful operational information concerning the feasibility of obtaining X-ray and γ-ray data from manned spacecraft. It is important to emphasize that the X-ray data obtained from celestial sources is for corroborative use only. Data with much higher angular resolution will be obtained from SAS-A experiments and be available prior to the fall 1971 launch of Apollo 16. The gamma-ray data is of potential scientific use because of the longer viewing time than that afforded by balloons.

III. Observation Times Required

The observation times for the X-ray and γ-ray experiments should be 1/2 hour for the galactic center, 1/2 hour for the galactic pole and 1/2 hour for the Crab Nebula. These observation periods may occur anytime in the 50 hour period after transearth injection, preferably as soon as possible. If additional time is available it should be devoted to observations of the galactic center, and if less time is available no observations of the Crab region should be made with an even split in time between the galactic pole and galactic center.

Because the count rates for the γ-ray experiment are typically 1/100 to 1/10,000 those anticipated for the X-ray experiment and due to the fact that the gamma-ray experiment is not bothered by the strong solar emission (the sun should contribute less than 5% of the background at 100 keV), it is recommended that the γ-ray experiment be left on for at least 50 hours during the transearth segment of the mission. The spacecraft may be in the PTC mode during this time. As a part of the existing experiment plan, the gamma-ray detector boom will be retracted during several hours of the transearth segment of the mission. This retraction is necessary to obtain background calibration data and should be adequate for the additional tasks suggested here for this experiment. Otherwise the boom should be fully extended during operation. The X-ray experiment should be left operating 5 hours with the power being removed from the proportional counters during the periods of solar viewing.

It is well to remember that statistics improve as the $\sqrt{\text{time}}$; thus 12.5 hours is only 50% reduction in the statistical accuracy from that obtained at 50 hours. Since balloons carry similar detectors for 6 hours or more, there is little advantage to operating for a period shorter than this.

IV. Background Possibilities for the Gamma-Ray Detector

The anticoincidence shield should provide adequate background rejection from charged particles. The generation of secondary gamma rays by the spacecraft is known to occur, but it is not possible to predict in advance the extent of this background contribution. This contribution will be identified from the data taken with the boom in the various retracted positions. Results from Rangers 3 and 5 indicate that the background induced by these spacecraft for a detector on a 6 ft boom was 10% of the natural diffuse flux.

V. Attitude Data

Concurrent spacecraft attitude data will be required with the X-ray and γ-ray experiment data taken during the PTC mode.

VI. Summary

It is recommended that the X-ray and γ-ray experiments be pointed at the three celestial regions previously mentioned for a total of 1.5 hours, and that the γ-ray experiment be left on 50 hours and the X-ray experiment 5 hours after the PTC mode is initiated.

Fred Tomblin

1011-FFT-sh F. F. Tomblin

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